Large-Scale Experiments of Fire Signatures to Develop a Discriminating Fire Detector

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Incorporating intelligence into a fire detector can provide the capability to promptly react to smoke while discriminating between smoke from fire and non-fire sources. The primary purpose of this study was to investigate the patterns of signatures associated with fire and environmental signatures via experiments. During the most recent phase of research, work is being conducted to supplement the small-scale experimental effort reported previously [1]. The research is being conducted at the University of Maryland by teams in the Departments of Fire Protection Engineering and Chemical Engineering. The fire protection engineering team is concentrating on identifying signatures from fire and non-fire sources. The chemical engineering team is investigating the applicability of neural networks to discriminate between fire signatures.

Initially, small-scale tests were conducted to characterize the signatures from fire and non-fire sources. The experiments were designed to be conceptually similar to those by Okayama [2], with modifications incorporated to provide a greater range of measurements for describing the signature.

The small-scale experimental apparatus was a simplified tunnel which included a means for generating odors, measurement equipment and sensors. Measurements of light obscuration, temperature, and gas species concentrations (CO, CO_2 and O_2) and presence of any oxidizable gas are provided. The presence of oxidizable gases was measured by a Taguchi metal oxide sensor. Sources of the smoke or odor were placed under a hood at the inlet end of the apparatus. Smoke and odors were produced from a wide range of conditions: samples with flaming and pyrolyzing combustion, heated samples and samples maintained at ambient conditions where the odor was introduced into the box via an atomizer. The specific fuels and environmental sources were intended to be representative of a residential environment.

The following patterns in the small-scale experimental data were evident: the maximum CO_2 concentrations for flaming fires were at least 1500 ppm, while the maximum CO_2 concentration for the non-flaming fires (pyrolzing fires, heated liquids and environmental odors) were all less than 1500 ppm. The non-flaming sources can be distinguished based on the CO and metal oxide sensor peak

measurements. All but three of the pyrolzing solids had peak CO concentrations of at least 28 ppm and a signal of less than 6 V from the Taguchi detector. Based on these observations, an elementary expert system appears to be capable of identifying the source of the odor.

The level of success attained from the small-scale experimental program indicated the feasibility of the concept presented by Okayama. However, the success of the expert system only relates to the limited range of fuel sources investigated and the small-scale test apparatus. A large-scale experimental program is being conducted to determine whether the trends identified in the small-scale experimental effort also can be observed in large-scale environments. The large-scale experiments being conducted at the University of Maryland are conceptually similar to the small-scale experiments. Signatures from fires and environmental sources involving a wide variety of fuel sources are monitored. As in the small-scale study, patterns are being sought, with the applicability of an expert system or neural network investigated.

The large-scale experiments are being conducted in a 12 x 12 ft room with a height of 8 ft. Measurements include temperature, mass loss of the fire sources, CO, CO_2 and O_2 concentrations and the voltage output from three different metal oxide sensors. The three metal oxide sensors respond to the presence of CO, oxidizable gas and environmental odors respectively.

In addition to the large-scale experiments being conducted, results from a wide variety of large-scale experiments conducted at international research institutions including NIST, VTT, SP, SINTEF and DIFT are being analyzed to describe early fire signatures. This data is useful to describe signatures only from flaming and non-flaming fuel sources, excluding signatures from environmental sources.

This work is ongoing. Analysis of experimental data and application of neural network will be reported.

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Selected References

[1] Milke, J.A., Denny, S.A, McAvoy, T.J. and Pan, D., "Initial Application of Neural Networks to Discriminate Between Fire and Non-fire Odors," presented at the Annual Conference on Fire Research, Rockville, MD, October 19, 1993.

[2] Okayama, Y., "Approach to Detection of Fires in Their Very Early Stage by Odor Sensors and Neural Net", Proceedings of the Third International Symposium of Fire Safety Science, 1991, p. 955-964.